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RESEARCH ARTICLE

Influence of abiotic factors in a population of *Parides ascanius* (Papilionidae, Lepidoptera) in an urban restinga fragment

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Abstract

Fragmentation and loss of natural habitats has reduced biodiversity in neotropical ecosystems. The restinga, a phytophysiognomy of the Atlantic Forest, has lost much of its original coverage and remains largely threatened by urbanisation. Restingas are considered hotspots of biodiversity and are listed as priority areas for conservation due to their great presence of endemic species, such as the endangered butterfly *Parides ascanius* Cramer, 1775. In this work, we analyse the influence of abiotic factors (temperature and humidity) on the abundance of *P. ascanius* in an urban restinga fragment of Iriry's Environmental Protection Area (Iriry APA), located in the municipality of Rio das Ostras in Rio de Janeiro. For that, the mark-recapture technique was used. Sampling was carried out from October 2017 to May 2018, between 7:00 am and 11:00 am. Seventy-two individuals of *P. ascanius* were collected and showed higher proportions of males over females and greater abundance of individuals in the month of October. On average, the number of individuals was significantly higher with the increase in air temperature and lower with the increase in air humidity. The abundance of *P. ascanius* at the restinga of Iriry APA varied monthly and temporally throughout the day, influenced by temperature and air humidity. The results provide information that can support management plans for conservation of this threatened species, as well as for urban areas of the Atlantic Forest.

Keywords
Atlantic Forest, butterflies, conservation, endemic species, fragmentation

Introduction

The disorderly urbanisation process has contributed to the loss of natural habitats, changing the environment and the availability of resources (Moura-Fujimoto 2000; Pimm and Raven 2000; Fahrig 2003; McDonald et al. 2008; Wu 2014; Liu et al. 2016). In Brazil, about 60% of the population lives in areas originally occupied by the Atlantic Forest biome, of which only 12% of its original coverage remains (Ribeiro et al. 2009; INPE 2017). The restinga, one of the phytophysiognomies of the Atlantic Forest, suffered intense fragmentation (Suguio and Tessler 1984; Rocha et al. 2007), resulting in a significant increase in numbers of species threatened with extinction (IUCN 2017; Freitas et al. 2018). The fragmentation of restinga areas can modify the biotic and abiotic pressures of resident populations, changing patterns of development and behaviour of species (May 1979; Rocha et al. 2007).

The butterfly *Parides ascanius* Cramer, 1775, an endemic species of the Atlantic Forest, has been threatened with extinction since the 1970s (Otero and Brown 1986; Almeida 2015) and according to the Brazilian Red Book of Threatened Species of Fauna (ICMBio 2018). One of the factors that aggravates the susceptibility to extinction of *P. ascanius* is the fact that they are monophagous during the immature phase, making them dependent on the host plant *Aristolochia trilobata* L., which is also endemic to the restinga ecosystem (Otero 1984; Herkenhoff et al. 2013).

Abiotic factors, such as temperature, humidity and precipitation, are known to have direct effect on the population density of insects (Freitas 2010; Cezar 2016). For butterflies, the increase in humidity negatively influences population density (Freitas 2010), while the increase in temperature and precipitation increases supply of floral resources and, consequently, the diversity of associated fauna (Cezar 2016; Scalco et al. 2016). Thus, climatic seasonality alters the diversity of lepidoptera in tropical regions, with a greater occurrence of butterflies in warmer seasons, such as in the beginning of spring and summer, reducing diversity in colder months, in late autumn and winter (Freitas and Ramos 2001; Paim and Di-Mare 2002; Scalco et al. 2016).

In this work, we analysed the influence of temperature and humidity on the abundance of *P. ascanius* in an urban restinga fragment. Studies that seek to understand the population variation of species over time, in response to biotic and abiotic variables, can provide important relevant information for the construction of management plans, which can enable more efficient maintenance of environmental protection areas.

Materials and methods

The Environmental Protection Area of Lagoa do Iriry (Iriry APA – Law 9.985 / 2000) is located within the urban area of the municipality of Rio das Ostras in Rio

de Janeiro, Brazil (22°30'39"S, 41°54'54"W) and comprises approximately 76.03 ha of restinga (760,300 m^2).

The Iriry APA is characterised by having three areas with different vegetation profiles and degrees of urbanisation interference (Fig. 1). Area 1 is characterised by greater proximity to urbanisation and recreation areas, with the presence of many exotic plant species. Area 2 is a strip of vegetation under a sandy stream flowing between a lagoon and the beach region. Area 3 has a higher concentration of shrubs and trees, with few open areas.

The fieldwork was carried out fortnightly from October 2017 to May 2018, from 7:00 am to 11:00 am, totalling 64 hours of sampling. On each day, a 760 m transect was placed, covering the three different areas of Iriry APA.

Individuals of *P. ascanius* were sampled using entomological net and classified (sex, age, alar damage, time and location of the capture), marked with non-toxic ink and subsequently released at the same capture site. The sex of each individual was classified according to the description of external genitalia characters, following Otero and Brown (1986), whereas other variables were classified according to Herkenhoff et al. (2013). Wings with no cuts and breaks were classified as 'without

Figure 1. Geographic location map of the study area showing the municipality of Rio das Ostras on the coast of the State of Rio de Janeiro, Brazil. To the right, a view of APA Iriry, numbers 1 to 3 indicate the different characteristics of the study area (1 = proximity to urbanisation and recreation areas, with the presence of many exotic plant species; 2 = a strip of vegetation under a sandy stream flowing between a lagoon and the beach region and 3 = a higher concentration of shrubs and trees, with few open areas.

damage'. Individuals with one to three cuts or one or two cuts and a rupture were classified as 'little damage'. In situations where individuals had more than three cuts or two or more breaks, they were considered 'too much damage'.

Classification of group age was estimated from the wing wear, being considered "younger individuals" i.e. those who did not present any wing wear. The intermediate individuals were those that showed some significant alar wear, but still showing colour patterns of the wings. Individuals classified as old were those who had colours of the wing already worn.

During each collection, abiotic data of temperature (°C) and relative humidity (%) of the air were registered. Weather data for Rio das Ostras municipality was obtained from the platform AccuWeather, Inc (https://www.accuweather.com).

The effects of abiotic factors over population parameters were estimated using Analysis of Variance (ANOVA) with Generalised Linear Models (GLM) in R software (R Core Team 2016). Residual analyses were performed in order to verify the adequacy of error distribution and models used (Crawley 2007). Comparisons between treatments were made using contrast analysis (Crawley 2007).

Results

Seventy-two individuals of *P. ascanius* were sampled, 41 males and 31 females. The number of *P. ascanius* individuals sampled in Iriry APA varied between months of collection ($F_{3.5}$ = 21.05; P = 0.002; Fig. 2), being significantly higher in October. Months with the lowest number of individuals collected were December/2017, April and May/2018.

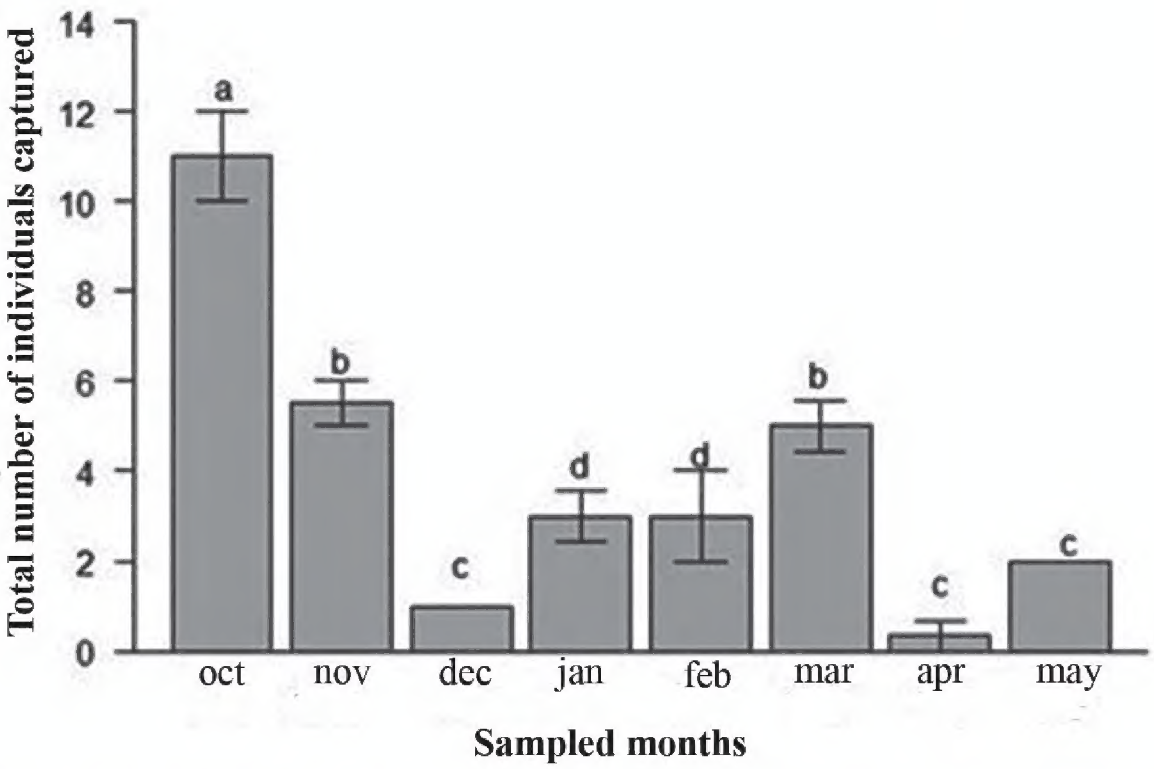

Figure 2. Number of individuals of *Parides ascanius* sampled in the Environmental Protection Area of Lagoa do Iriry, Rio das Ostras, Rio de Janeiro, from October 2017 to May 2018. The bars represent the standard error, different letters represent significantly different values.

The sex ratio found for *P. ascanius* in Iriry APA varied over months, except for December (Fig. 3).

The number of *P. ascanius* individuals collected and classified as 'new' followed the same trend as the number of total individuals over months (F7.12 = 23.83; P < 0.001; Fig. 4), with greater number of new individuals in October. The number of individuals collected and classified as 'intermediate' (F7.12 = 0.72; P = 0.65) and 'old' (F7.12 = 1.79; P = 0.17) did not differ significantly between months.

Number of *P. ascanius* individuals collected and classified as 'without damage' ($F_{3.5}$ = 0.89; P = 0.50), 'little damage' ($F_{3.5}$ = 3.44; P = 0.10) or 'too much damage' ($F_{3.5}$ = 0.02; P = 0.99) did not differ significantly over months. Amongst young individuals, only one presented a high alar damage category.

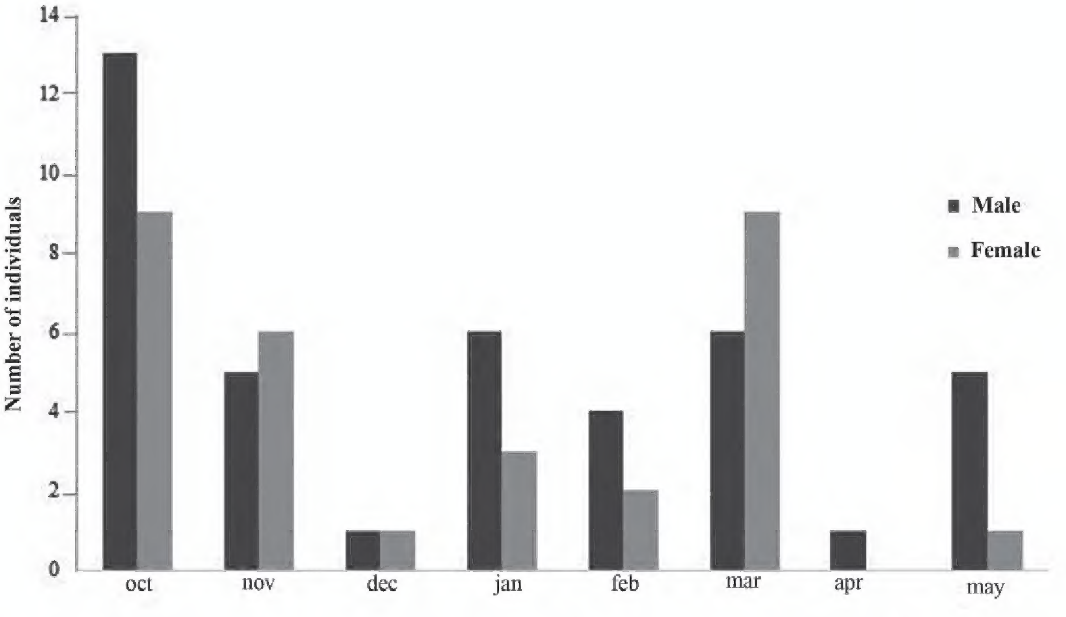

Figure 3. Sexual proportion of males and females of *Parides ascanius* sampled in the Environmental Protection Area of Lagoa do Iriry, Rio das Ostras, Rio de Janeiro, from October 2017 to May 2018.

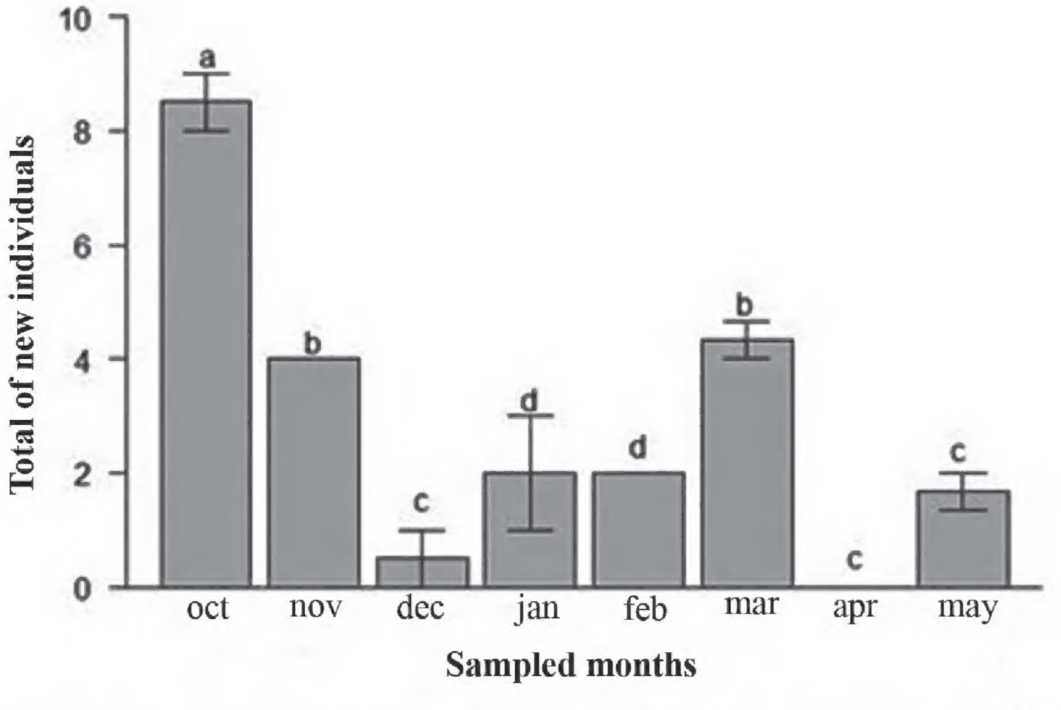

Figure 4. Number of individuals of *Parides ascanius* collected and classified as 'new' in the Environmental Protection Area of Lagoa do Iriry, Rio das Ostras, Rio de Janeiro, from October 2017 to May 2018.

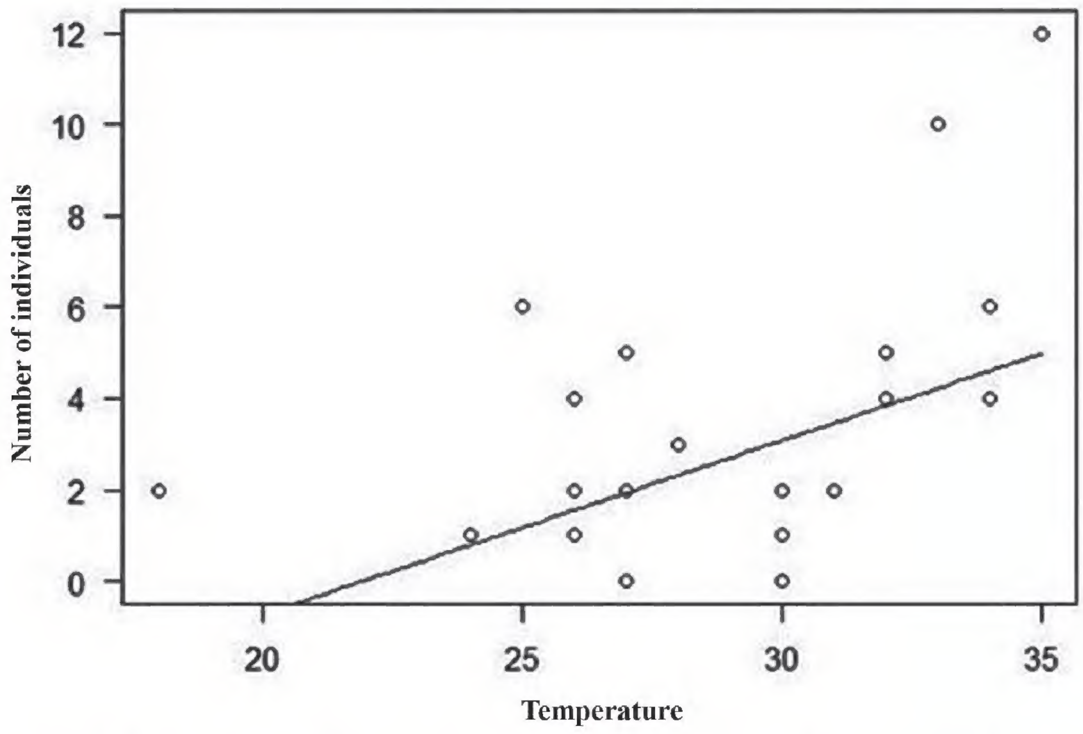

Figure 5. Relationship between the number of individuals of *Parides ascanius* and temperature ($F_{1.18}$ = 6.16; P = 0.023) in the Environmental Protection Area of Lagoa do Iriry, Rio das Ostras, Rio de Janeiro, from October 2017 to May 2018.

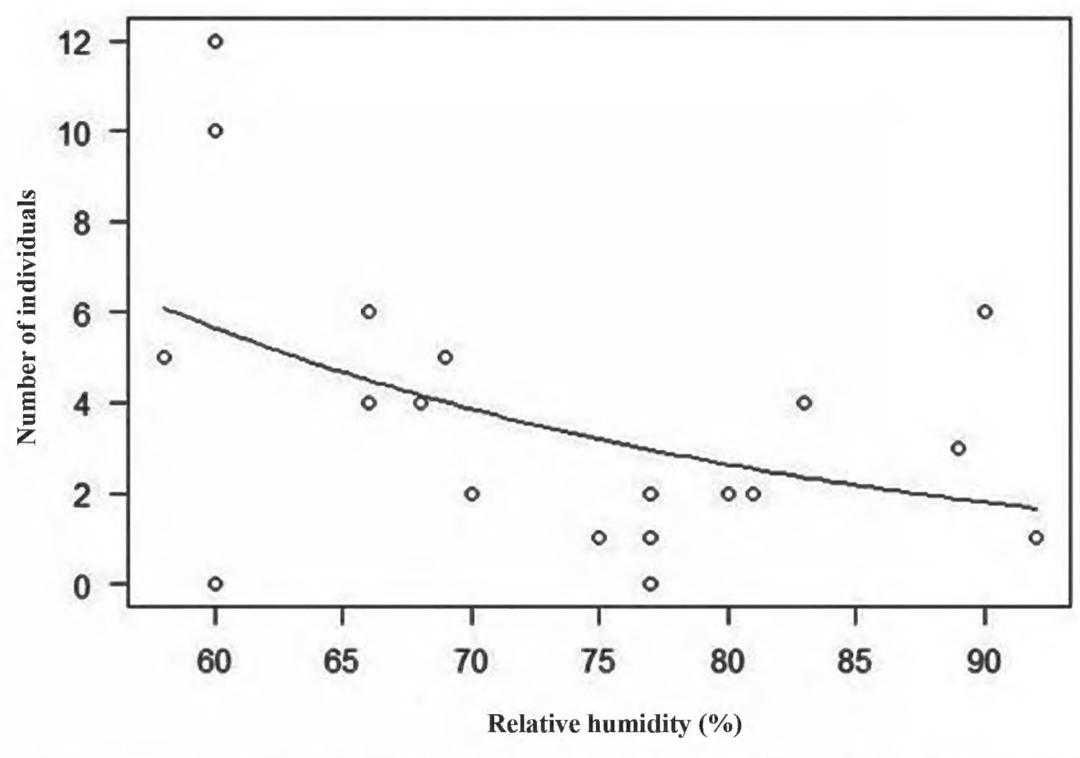

Figure 6. Relationship between the number of individuals of *Parides ascanius* and humidity of the air ($F_{1.18}$ = 4.21; P = 0.05) in the Environmental Protection Area of Lagoa do Iriry, Rio das Ostras, Rio de Janeiro, from October 2017 to May 2018.

A relationship between number of individuals of *P. ascanius* and abiotic conditions was found with the number of individuals being significantly higher as air temperature increases (F1.18 = 6.16; P = 0.023, Fig. 5) and significantly lower as air humidity increases (F1.18 = 4.21; P = 0.05, Fig. 6).

Discussion

The number of individuals collected was lower than that already reported in literature for other restinga environmental preservation areas in the State of Rio de Janeiro. Otero and Brown (1986) sampled 100 individuals between August and December in Barra de São João (RJ), while Herkenhoff et al. (2013) sampled 307 individuals in Poço das Antas Biological Reserve (RJ), between October 2004 and September 2005. However, Poço das Antas Reserve is an area about 66 times larger than Iriry APA. Smaller areas have greater proximity between their edge and interior, which intensifies edge effects and can lead to smaller number of individuals in populations more sensitive to abiotic changes (Pascual-Hortal and Saura 2006; Saura and Rubio 2010).

P. ascanius populations have already been registered in several urban parks that have restinga areas in Rio de Janeiro, such as Chico Mendes Municipality Park (Vianna and Verçoza 2011), Marapendi Nature Park (Melo et al. 2018), Tijuca National Park (Smac 2000) and Bosque da Barra Park (Almeida 2015), which demonstrates the importance of urban vegetation fragments for the maintenance of threatened native species.

This pattern is similar to that found by Otero and Brown (1986) in Barra de São João (RJ), whose maximum value was 19 individuals sampled in October. In Poço das Antas Biological Reserve (RJ), the population peak occurred in September, with a maximum of 39 individuals (Herkenhoff et al. 2013). This occurrence peak of *P. ascanius* during spring season (September to December) is a pattern already described for other species of Papilionidae (Brown 1996; Brown and Freitas 2000). Studies on population biology of these butterflies have shown that spring is the season of the year with the highest population density, a reflex to an increase in average temperatures and resources that stimulate the break of the diapause state, common during the winter (Freitas and Ramos 2001; Scalco et al. 2016).

Lower proportion of females, observed in some months, may be associated with behavioural and physiological differences, since females are more sedentary and have less longevity (Freitas and Ramos 2001; Herkenhoff et al. 2013; Seraphim et al. 2018). In addition, females tend to disperse more in search for oviposition sites and, when they produce eggs, they tend to reduce flight time as a strategy to allocate energy for reproduction (Seraphim et al. 2018). Baguette et al. (1998) described the competition of males to copulate causes significant harassment that can contribute to the migration of females. In addition, males can travel great distances attracted by the presence of fertile and receptive females.

The occurrence of young individuals in all sampled months may indicate that the species reproduces in all seasons. However, the increase in number of young individuals in October may indicate that spring is more conducive to reproduction. In fact, butterflies diapause in pupa phase, especially in colder seasons (Otero and Brown 1986; Caporale et al. 2017), which may explain the low number of individuals between April and May.

Amongst young individuals, only one presented a high alar damage category, which may be a consequence of predation, competition or movement in the vegetation. Similar results with larger numbers of young and intermediate individuals in the low damage category have also been described for a population of *P. ascanius* from the Poço das Antas Biological Reserve (Herkenhoff et al. 2013).

The greater number of individuals sampled at higher temperatures may be related to thermoregulation, a mechanism that allows insects to maintain body temperature above or below room temperature, through behavioural or physiological means (Heinrich 1993; Iserhard et al. 2017). Amongst the strategies used as means of regulating temperature are adaptations for greater absorption of the sun's rays, selection of micro-habitat and changes in standard activities or colouring (May 1979; Rossato et al. 2018). In this sense, the black colouring of the wings of *P. ascanius* is a characteristic that can affect its thermoregulation, causing a greater absorption of heat, allowing flights even in periods of the day with lower temperatures.

Conclusions

The abundance of *P. ascanius* in a restinga area in APA Iriry varied monthly and temporally throughout the day, influenced by abiotic factors, temperature and air humidity. The Iriry APA is a small urban restinga fragment that houses host plants which allow the maintenance of a population of an endemic restinga species which is threatened with extinction in Brazil. The results of this study provide information that can contribute to *P. ascanius* management and conservation plans and highlights the importance of conservation and maintenance of APA Iriry, Rio das Ostras, Rio de Janeiro.

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